Overview of the Amazonian vegetation in Maranhão: floristic richness of Anajatuba

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Key words:
- Checklist
- Conservation Unit
- Digital tools
- Gaps

Abstract

The Amazonia domain in Maranhão has high biodiversity but only a small portion is protected by Conservation Units. This study analyzed the vegetation in Anajatuba and focused on angiosperms. The compilation involved searching the speciesLink and Reflora platforms and prioritizing the most recent vouchers identified and deposited in herbaria. We compiled 493 records that represent 220 species. Due to their growth habits and dispersal mechanisms, Fabaceae and Asteraceae were the most diverse families, while Poaceae and Cyperaceae had the fewest records. The species with the most records are associated with food use or common in anthropogenic areas. Records of herbaceous strata are prevalent, and there are few records of woody species and palms. Most species are native; however, some exotic and cultivated species were also found, highlighting potential risks to the native flora. Only *Handroanthus impetiginosus* was recognized as near threatened. The study identified a 10-year gap in floristic records for the area, emphasizing the need for updating floristic data, especially due to the rise in deforestation and the need for conserving Amazonia in Maranhão.

Palavras-chave:
- Checklist
- Unidade de Conservação
- Ferramentas digitais
- Lacunas

Resumo

A Amazônia maranhense é um importante reservatório de biodiversidade com apenas uma pequena parcela protegida por Unidades de Conservação. Este estudo analisou a vegetação de Anajatuba, investigando registros de Angiospermas. Foram compilados 493 registros, abrangendo 220 espécies. Fabaceae e Asteraceae se destacaram pela diversidade, enquanto Poaceae e Cyperaceae tiveram poucos registros. Muitas espécies registradas são de uso alimentar ou comuns em áreas antropizadas. O estrato herbáceo é predominante, evidenciando a falta de coletas de espécies lenhosas e palmeiras. A maioria das espécies é nativa, embora algumas exóticas e cultivadas, destacando possíveis riscos à flora nativa. Apenas *Handroanthus impetiginosus* foi classificada como quase ameaçada. O estudo aponta uma lacuna de 10 anos nos registros, reforçando que os registros florísticos são necessários para atualizar os dados sobre a biodiversidade na região, especialmente diante do aumento do desmatamento que apoiam a necessidade de conservação da Amazônia maranhense.

Original Papers

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See supplementary material at <https://doi.org/10.6084/m9.figshare.29577410.v1>

Cite as: Rabelo TO, Carvalho US, Sousa FC, Candido DS, Nascimento ALB & Almeida Jr. EB (2025) Overview of the Amazonian vegetation in Maranhão: floristic richness of Anajatuba. Rodriguésia 76: e00942024. DOI: 10.1590/2175-7860202576031

Area Editor: Dr. Carlos Daniel Miranda Ferreira
Received on November 12, 2024. Accepted on May 09, 2025.

Rodriguésia
Revista do Instituto de Pesquisas Jardim Botânico do Rio de Janeiro <http://rodriguesia.jbrj.gov.br>.

Introduction

Amazonia is the most extensive and rich tropical forest on the planet and makes up 49.29% of Brazil, where it occurs in the states of Acre, Amapá, Amazonas, Maranhão, Mato Grosso, Pará, Rondônia, Roraima, and Tocantins (Brancalion *et al*. 2012; IBGE 2023). It is an important reservoir of national biodiversity that conserves more than 12,000 angiosperm species, of which 2,519 are endemic to the country (Flora e Funga do Brasil 2025, continuously updated).

In Maranhão, the Amazonia domain has undergone various changes due to constant anthropogenic pressures. This has caused a reduction in biodiversity and climate and biological imbalances (De Sá Araújo 2020). Despite that its vegetation is under great risk, only 17.66% of Amazonia in the state is protected by Conservation Units, notably the Área de Proteção Ambiental da Baixada Maranhense (APA) and Gurupi Biological Reserve (REBIO) (Silva *et al*. 2005; De Almeida & Vieira 2010).

Baixada Maranhense is a state environmental preservation area created (by Decree nº 11.900 on 11 June 1991) to regulate land use and occupation, as well as the exploitation of natural resources. It is a huge area of flooded land formed by rivers and lakes in the west, north, and center of Maranhão State (Tozato 2017; SEMA 2023). This microregion is approximately 1,775,035 hectares and encompasses around 23 municipalities and around 20 thousand km^2 of the Amazonia Legal in Maranhão (IBGE 2023). Due to the significant role it plays in conserving species and regulating the hydric regime and climate, it was designated as an important international wetland by the Ramsar Convention (Silva Junior *et al*. 2016).

For the APA Baixada Maranhense, Martins & Oliveira (2011) attested to the quantity of threatened, rare and endemic species that occur in this area and the environmental importance of the region to Brazil, which generated great concern because a lot of the biodiversity in Conservation Units has been lost before it was even known (Borém & Oliveira-Filho 2002).

Thus, sampling the floristic composition of these areas is an important step to understanding an ecosystem (*e.g*., the ecological causes and effects that act on an environment) and supporting subsequent studies about many subjects, as well as government actions related to evaluating environmental impacts and recuperating degraded areas (Caiafa 2002).

Despite the existence of floristic studies conducted in the region in recent years, our knowledge about this subject is limited to few municipalities and mostly about aquatic macrophytes (Barbieri & Pinto 1999) and ethnobotanical surveys (Rêgo 1988; Amorim *et al*. 2022). Most of the records of plants species in APA Baixada Maranhense are listed on virtual platforms, such as speciesLink and Reflora.

Do to this and the potential importance of the flora in the Amazonian region of Maranhão, the objective of the present study was to inventory the angiosperm flora in Anajatuba, a municipality that belongs to the APA Baixada Maranhense, Brazil. Were also including data about the presence of endemic and threatened species. This will serve as a base to analyze the characteristics and conservation status of this APA.

Material and Methods

Study area

The municipality of Anajatuba is in Maranhão state, in the Northeast Region of Brazil, and within the microregion of Baixada Maranhense between the coordinates 03º01'15''S and 44º25'40''W (Fig. 1). It is 393 km from the state capital, São Luís, and has an area of 1,117 km² and 25,294 inhabitants (IBGE 2010).

The urban region of Anajatuba is on the margins of inundated fields (Chagas 2006). During the rainy season, the lower areas in the Anajatuba floodplains become inundated, forming temporary lakes in the region. The hydrographic network mainly comprises the Mearim River and its tributaries. According to the classification by Köppen (1948) and adapted by Corrêa *et al*. (2023), the climate is Aw (tropical with rain the summer and fall). The average temperature is 27 ºC, with little seasonal variation, and the annual precipitation ranges from around 1,800 mm to 2,000 mm (Chagas 2006).

The area has a rich transition vegetation between the *Cerrado* and Amazonia, including palm forests, gallery forests, and inundated fields (Fig. 2) (Costa-Neto *et al*. 2002). The plant species vary in different habitats, from lower periodically inundated fields, which have more aquatic macrophytes, to Amazonian forest formations in dryer regions at higher elevations. In the latter, the arboreal stratum is prevalent and has an average height of 12.2 meters according to an estimate by Rocha *et al*. (2020).

According to Golfari (1980), the arboreal vegetation is similar to liana forest that occurs in Amazonian forest and is characterized by trees of medium height and a reduced canopy. Additionally, there are lianas in the soil and around trunks. Some arboreal species are taller than the canopy (*e.g*., palms) and can exceed 25 meters.

The dense Amazonian vegetation that predominates in Anajatuba is vital to the climate, hydric resources, biodiversity, and traditional

communities in the region (Santos Filho *et al*. 2010). This vegetation contributes to the local economy in relation to agriculture, livestock, extraction of wood, and non-wood forest products used for food and medicines (Rabelo *et al*. 2022).

Compiling the floristic data

Using the speciesLink (<https://specieslink.net/>) and Herbário Virtual Reflora (<https://floradobrasil.jbrj.gov.br/reflora/herbarioVirtual/>) platforms, we searched for specimens from the municipality of Anajatuba to gain more information on historical records of the local flora. In this context, information on the platform about the botanical collections and distribution data at the municipality, state and country levels were filtered, resulting in 493 records.

Following this, voucher specimens in the databases were analyzed. The specimens were chosen according to the most recent collection date, with priority given to those in Maranhão herbaria and identified by specialists compared to non-taxonomists.

The list includes information about habit, origin, collection year, herbarium voucher number, and geographic coordinates, which serve as a base to understand the quality of the data recorded for the flora of the municipality. The families, the names of the taxa, synonyms, and habit of the species were updated following information on the Flora e Funga do Brasil site (<http://floradobrasil.jbrj.gov.br/>). Threatened species were recognized based on the Lista oficial das espécies ameaçadas de extinção (MMA 2014). Specimens that had questionable identifications or that did not occur in Brazil were excluded.

Results and Discussion

We compiled 493 records that correspond to 220 species, 163 genera, and 74 families. The family Fabaceae was the richest, with 41 species, followed by Asteraceae (15 spp.), Malvaceae, Myrtaceae and Solanaceae (8 spp. each), Rubiaceae (7 spp.), and Euphorbiaceae and Malpighiaceae (6 spp. each) (Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.29577410.v1>). These families are common in Maranhão, and they are the richest families in floristic studies that have been conducted in the state (Almeida Jr. *et al*. 2017; Silva *et al*. 2022).

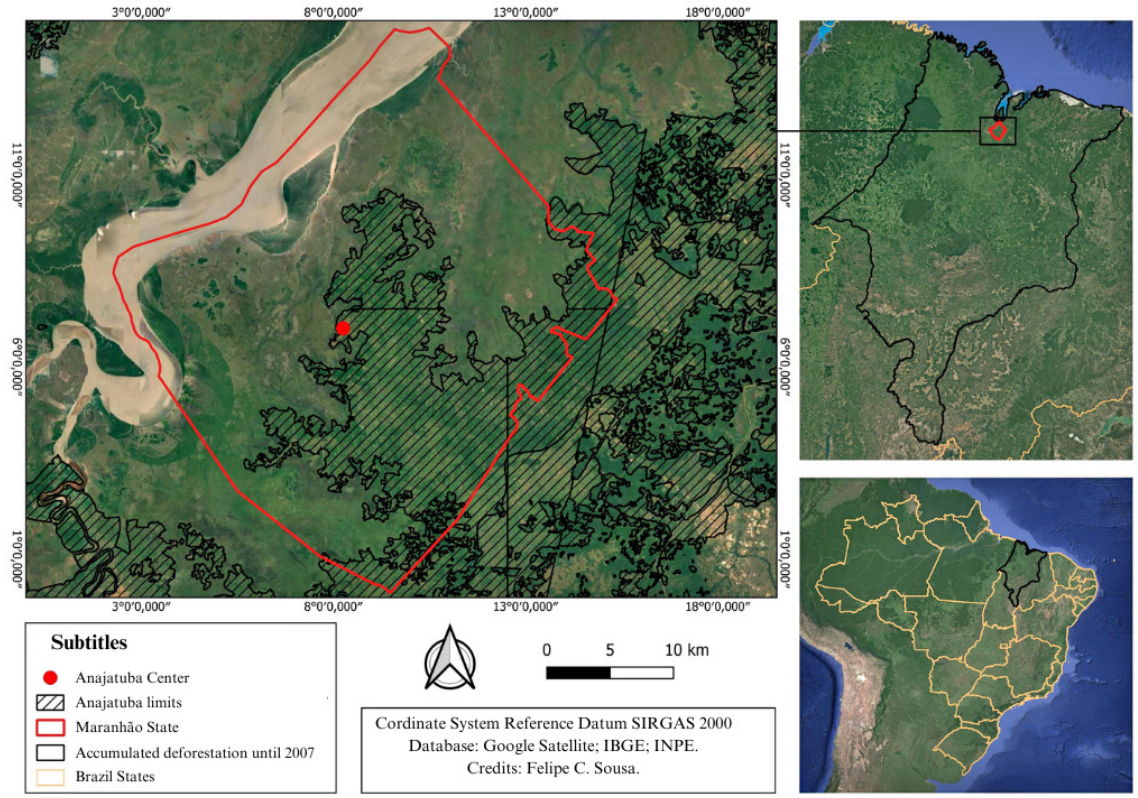

Figure 1 – Location map of the municipality of Anajatuba, Maranhão.

Figure 2 – a-e. Vegetation in the municipality of Anajatuba – a. forest area with flooded areas near floodplains; b. lakes with aquatic macrophytes; c. clearing in the middle of terra firme forest; d. forest with Amazonian characteristics and dense vegetation in terra firme forest; e. babaçu in a cocais forest area.

The family richest in species in Brazil is Fabaceae (BFG 2022; Flora e Funga do Brasil 2025, continuously updated); its species are adapted to different environments, including anthropogenic areas, which justifies it being the richest family in the present study. The third richest family in Brazil is Asteraceae (BFG 2022), which also has widely distributed species, especially in disturbed areas; the species produce numerous seeds and fruits that are generally anemochorous, which aids in their dispersal (Funk *et al*. 2005).

These families were also found to be highly rich in the following: an urban fragment in Parque Estadual do Sítio do Rangedor, a Conservation Unit that has a strong human presence (Almeida Jr. *et al.* 2021); Sítio Santa Eulália (Silva *et al*. 2022); and in the work of Costa & Almeida Jr. (2022), who analyzed the composition and distribution of the arboreal flora on Campus Dom Delgado of Universidade Federal do Maranhão (UFMA).

In contrast, Cyperaceae and Poaceae, which are reported in the literature to be highly rich families, are underestimated for Anajatuba. This is due to the scarcity of floristic studies about Baixada Maranhense, especially for these groups (Costa & Almeida Jr. 2020). The lack of taxonomic studies about these groups of monocotyledons in this ecosystem is also evident; most taxonomic works have been conducted in the dunes and restinga on São Luís Island (Dias & Almeida Jr. 2017).

The species with the most records were *Anacardium occidentale* L., *Borreria verticillata* (L.) G.Mey., *Turnera ulmifolia* L., *Solanum tricuspidatum* Dunal, *Senna alata* (L.) Roxb., *Tamarindus indica* L., and *Tilesia baccata* (L.) Pruski. *Borreria verticillata* and *T. ulmifolia* are widely encountered in anthropogenic areas and easily disperse and grow (Albuquerque & Lucena 2005). *Anacardium occidentale* and *T. indica* are more numerous because they are managed and used as food (Gomes *et al*. 2020; Amorim *et al*. 2022).

Among the species that were surveyed in this study, we found one record of *Tontelea attenuata* Miers for the state of Maranhão. This species was registered once in 1947 and is archived in the herbarium of Instituto Nacional de Pesquisas da Amazônia (INPA). The main specimen was identified by a specialist of the group, in 1999, as belonging to the genus *Salacia* L. This record highlights the importance of making new collections in the municipalities to update information about the flora and improve our understanding of its richness and diversity.

Herbs are the most recurrent plants in the study area, with 65 species, followed by trees (57 spp.), shrubs (49 spp.), subshrubs (25 spp.), vines (16 spp.), and lianas (8 spp.) (Fig. 3). The prevalence of the herbaceous stratum is because there are diverse natural physiognomies in the region where herbs like to grow, such as flooded fields and forest vegetation with thin canopies, as well as forest fragments resulting from anthropogenic disturbances that cleared areas. This allows sunlight to easily enter the vegetation, which favors the development and expansion of smaller plants in the understory (Golfari 1980; Almeida Jr. 2021).

According to a study by Carvalho *et al*. (2016), the woody species castanheira, gameleira, and cedro are popular names mentioned in the region,but no records of herbarium specimens were found, impossible to confirm the taxonomic status of these taxa in Anajatuba. This lack of data highlights the need to expand our knowledge about the region's arboreal component, since previous studies focused primarily on herbs and shrubs (Carvalho *et al.* 2016; Rabelo *et al.* 2022).

Species of babaçu (*Attalea speciosa* Mart. *ex* Spreng.), buriti (*Mauritia flexuosa* L.f.), buritirana (*Mauritiella armata* [Mart.] Burret), and carnaúba (*Copernicia prunifera* [Mill.] H.E.Moore) are common in the region (Correia Filho 2011). The lack of records of these palms in herbaria is because they are difficult to collect, and this is influencing the reported distributions of these plants (Fisch *et al*. 2015).

For origin, we recorded 177 native, 22 naturalized, and 21 cultivated species. The naturalized and cultivated species were kept on the list, as well as ruderal species that have a potential use. We did this because most of the records were linked to studies related to Quilombola and rural traditional communities in the region and evidence the use of ruderal species and management practices for exotic species (Carvalho *et al*. 2016; Rabelo *et al*. 2022).

Catharanthus roseus (L.) Don, *Impatiens walleriana* Hook.f., *Neustanthus phaseoloides* (Roxb.) Benth, and *Syzygium cumini* (L.) Skeels are invasive species. These plants are used as ornamentals and, in the case of *S. cumini*, as food (Instituto Hórus 2025). Recognizing these plants is fundamental for conservation, since the introduction of invasive species is the second greatest cause of biodiversity loss in the world (IUCN 2000). Invasive species compete with native species and obscure the true richness of the flora in the region.

Of the 220 species recorded, the conservation status of 199 has not been assessed. Twenty species have been classified as Least Concern. *Handroanthus impetiginosus* (Mart. *ex* DC.) Mattos has been assessed as Near Threatened, which is due to the risk of overexploiting this species for its wood (Santos Filho & Messina 2012). It is important to conduct new studies about the conservation status of the plants because most have not been assessed.

Many of the records from Anajatuba were made between 1947 and 2009. After this period, new records were only noted starting in 2019,

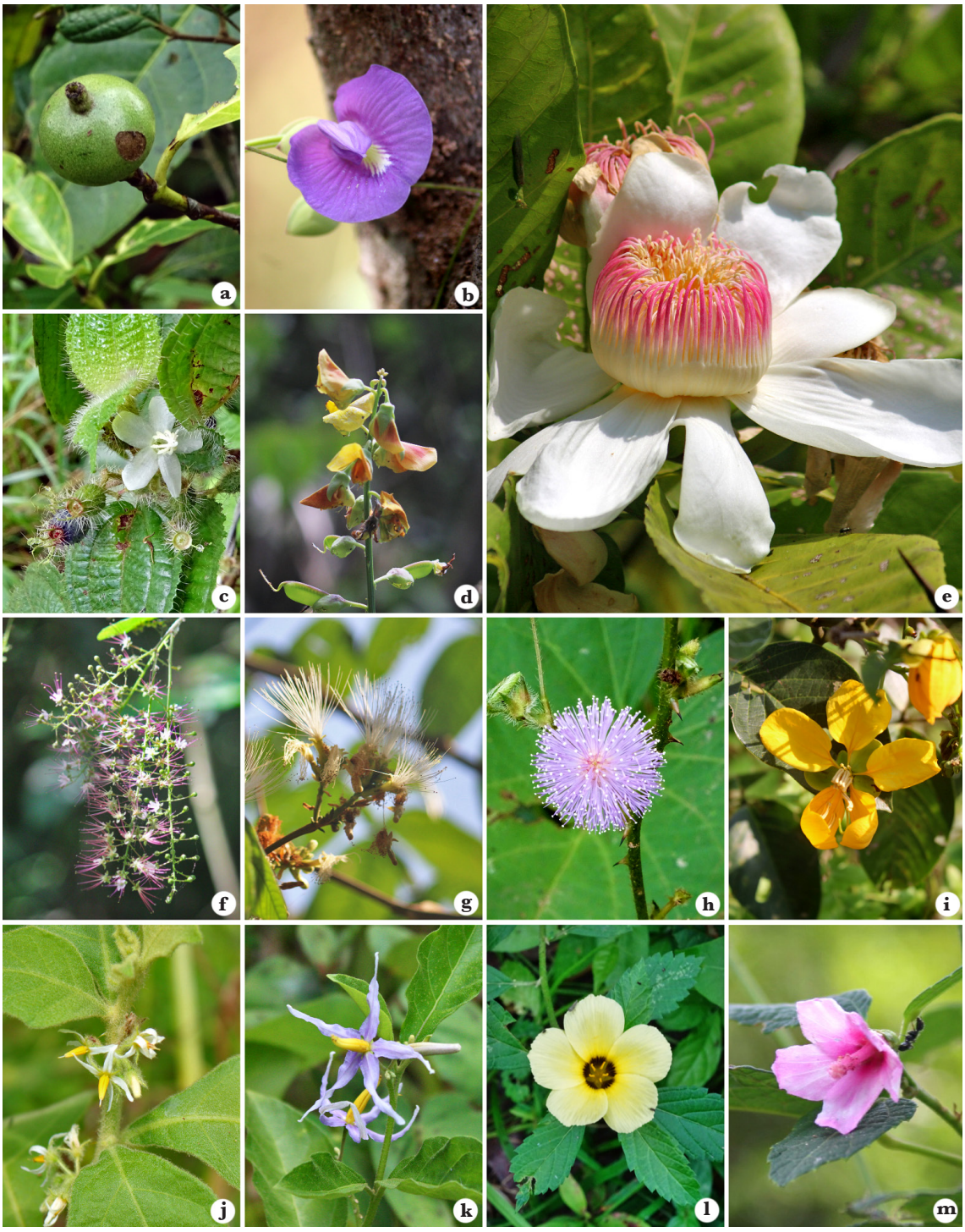

Figure 3 – a-m. Species recorded in Anajatuba, APA Baixada Maranhense, Maranhão, Brazil – a. *Alibertia edulis*; b. *Centrosema brasilianum*; c. *Clidemia hirta*; d. *Crotalaria retusa*; e. *Gustavia augusta*; f. *Hirtella racemosa*; g. *Inga edulis*; h. *Mimosa pudica*; i. *Senna georgica*; j. *Solanum jamaicense*; k. *Solanum subinerme*; l. *Turnera subulata*; m. *Urena lobata*. Images: Authors (2023).

showing a gap in floristic studies for the region. The lack of collections during this period suggests a data lag, especially considering the occupation and deforestation in Baixada Maranhense in the last five years for cattle and soybean farming, which has suppressed the native vegetation (Farina 2006).

Among these records, M. Ribeiro and B.G.S. Ribeiro are notable researchers for their documentation of around 300 plants recorded in the databases consulted that are archived in the Herbarium of Empresa Brasileira de Pesquisa Agropecuária (Embrapa) and Amazônia Oriental (IAN). It can be inferred that the surveys in the region resulted from inventories conducted by Embrapa in Baixada Maranhense during the period when it implemented projects in the area (Valladares *et al*. 2005; EMBRAPA 2006). Many of the records in herbaria in the state, such as Herbaria Rosa Mochel (SLUI) and of Maranhão (MAR), are from 2018 and 2019. This may be associated with a period marked by increased financial support and more activity by researchers and students at these institutions.

These records are important because the study area is a sustainable use Conservation Unit that has become degraded due to forest fragmentation. Additionally, there has been an increase in less dense or shrub vegetation and the suppression of denser vegetation due to cattle farming (Santos *et al*. 2020). This study also affirmed that there was urban growth in the region based on satellite images from 2000 to 2014, which may contribute to the expansion of intensively cultivated landscapes and an increased reliance on exotic and ruderal species (Reis & Conceição 2010).

This study highlights the importance of plant records for understanding and documenting the flora of Anajatuba and increases what is known about the flora and collection history in the region. The records we analyzed provide more information about species richness, suggest the need for new studies in Maranhão, and highlight the importance of herbaria to catalog species that are still poorly collected.

Thus, the data obtained help us better understand the floristic history of the region and highlight collection gaps in different ecosystems and arboreal strata in the municipality. Additionally, we emphasize the need to better understand the biodiversity in the region and to update collections from the region, which were mostly made over two decades ago.

Acknowledgements

We thank the following: the Fundação de Amparo e Pesquisa do Maranhão (FAPEMA), for the funding for the project; the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), for the Productivity Grant awarded to the last author (316031/2021-6); the Coordination for the Improvement of Higher Education Personnel (CAPES), for the support (finance code 001); the PDPG AMAZÔNIA - LEGAL (Project Nº: 0762/2020/88881.510069/2020-01), for the funding for the project; the Pós-graduação em Biodiversidade e Conservação at UFMA (PPGBC), for the training and research opportunities; the Laboratório de Estudos Botânicos (LEB), for the technical support; and UFMA and the Herbário do Maranhão (MAR), for the physical space, access to the collection, and assistance with species identifications.

Data availability statement

In accordance with Open Science communication practices, the authors inform that all data used in this manuscript is publicly available.

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